How Efficient Are New Homes in California?

The Issue

Energy-efficiency standards for homes have the potential to reduce energy consumption and peak electrical demand. Existing standards can improve the performance of homes built to those standards, but little data is available on the actual energy performance of new homes.

The Solution

The Efficiency Characteristics and Opportunities of New California Homes project examined 40 single-family and 40 multifamily units (apartments and townhouses) that were built under the 2005 Building Energy Efficiency Standards for Residential Buildings. Data gathered in the field on lighting, heating, ventilation, and air conditioning (HVAC) and other characteristics showed that the homes often did not perform up to code. In a second phase of the project, HVAC upgrades were implemented in nine of the homes, and the improvements were then measured.

The findings point to areas in the existing codes that are in need of revision to capture efficiency opportunities. The project includes a list of recommendations for the 2013 version of the Energy Efficiency Standards for Residential and Nonresidential Buildings, Title 24.

Features and Benefits

The data gathered during the Efficiency Characteristics and Opportunities of New California Homes project characterized the energy performance and air quality of newer homes in the areas of lighting, formaldehyde concentrations (a common indoor air pollutant), HVAC performance, and air leakage from fireplaces, and from the homes as a whole.

Lighting. Although not violating existing Title 24 energy-efficiency standards, inefficient incandescent lighting was the most common light source—78 percent of the lighting wattage in single-family and townhouses was incandescent, while 12 to 13 percent was compact fluorescent. Apartment buildings had 68 percent incandescent bulbs and 20 percent compact fluorescent lamps (CFLs). Most of the lamp wattage was controlled by switches, with some dimmers and occupancy sensors (**Figure 1**).

Formaldehyde. Formaldehyde concentrations in 75 of the 80 homes were higher than the chronic reference exposure level of 2.4 parts per billion (ppb). The reference exposure level is a concentration at or below which adverse health effects are not likely to occur. Chronic reference exposure levels are set by the California Office of Environmental Health Hazard Assessment. It is common for formaldehyde levels to exceed reference exposure levels in indoor environments.

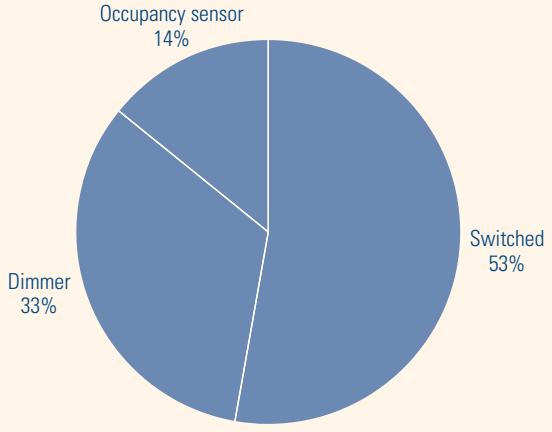
HVAC. Researchers found several problems that decreased HVAC system efficiency, including problems with airflows, refrigerant system components, and ductwork. Airflow for cooling was particularly problematic. Although there are no requirements in the 2005 code, only 28 percent of the systems tested would have met the 2008 California Title 24 standards for cooling airflow and fan power. Low airflows also occurred in the heating mode.

The predominant cause of low airflows was excessive static pressure in the return ducts—a result of inadequate return grilles and ductwork, as well as the use of a high-pressure drop filter. Several recommendations for the 2013 Title 24 energy-efficiency standards revolved around these findings, including a suggestion for a minimum airflow of 400 cubic feet per minute per ton of cooling capacity, and a requirement that HVAC filters be clearly labeled with a clean filter pressure drop and airflow performance data.

Researchers also found problems with the thermostatic expansion valves. Thermostatic expansion valves control the flow of

Figure 1: Lighting controls

Switching was the dominant form of lighting control. Multifamily units featured fewer dimmers and occupancy sensors than the single-family units shown here.



Source: Bruce Wilcox

refrigerant to maintain a nearly constant refrigerant temperature difference between the coil entrance and exit points.

Duct leakage for most of the single-family homes met Title 24 2005 requirements, with higher leakage rates in multifamily units. However, researchers note that duct leakage causes three problems: conditioned supply-air loss, return-air dilution, and additional house infiltration. Researchers believe that the effect of this infiltration has been underestimated in past Title 24 calculations, and they recommend that a new duct leakage imbalance value be used. These effects are most severe when ducts run through the attic, which occurred in 78 percent of the homes.

Researchers also found that most furnace blower cabinets were not insulated, which causes excessive heat gain in the summer and heat loss in the winter. They note that the federal furnace standards consider the fan cabinet as part of the duct system, which means it must be insulated to the levels specified for duct systems.

HVAC upgrades. Repairs and upgrades to the HVAC systems in nine homes resulted in an average efficiency improvement of 24 percent. The most common measure was to reduce the flow resistance in the return duct between the house and the HVAC equipment through the use of high-flow filters and additional returns and increased return-air grille sizes (**Figure 2**). Refrigerant change-outs improved performance in two homes, and in one case an upgrade to brushless permanent magnet motors increased efficiency by 4 percent.

Fireplace air leakage. Fireplaces are reputed to be big sources of air leakage, but little data is available on leakage rates. In this study, where mostly gas fireplace units were found, fireplace leakage ranged from less than 2 percent to 18 percent.

House air leakage. Researchers found the single-family homes to be reasonably tight, while apartments and townhouses showed significantly higher leakage rates. In homes with accessible attics and garages, 51 percent of the leakage occurred between the living space and the attic, and 11 percent occurred between the living space and the garage.

Applications

The data gathered in this study will help researchers, government officials involved with building codes, and construction industry personnel understand the characteristics of new homes and where there is room for improvement. The data should also help inspectors identify potential trouble spots as they check for code compliance.

Figure 2: Reducing flow resistance

In this home, the return-air grille was enlarged and a duct was added to reduce flow resistance.

Source: Bruce Wilcox

California Codes and Standards

Researchers developed a set of recommendations for the 2013 Title 24 standards that cover a number of topics, including airflow requirements, duct leakage, and thermal expansion valves.

What's Next

Researchers found that noncondensables (non-liquid particulates) were present in the refrigerant of some of the air conditioners they examined. Noncondensables decrease system efficiency, and the researchers recommend additional field research to determine the extent of the problem.

Collaborators

The project team included Bruce Wilcox PE, Proctor Engineering Group Ltd., and Chitwood Energy Management Inc., with support from Pacific Gas and Electric Company, Southern California Edison, and Sempra Utilities.

For More Information

For more information on this project, please contact the California Energy Commission researcher listed below.

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About PIER

This project was conducted by the California Energy Commission's Public Interest Energy Research (PIER) Program. PIER supports public interest energy research and development that helps improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

CEC-500-2011-TB-004
December 2011